US Army Corps of Engineers
Waterways Experiment Station

Consortium News—

Newsletter of the SERDP Biotreatment Research Consortium

Volume 1, Number 1

October 1995

What is the SERDP Biological Treatment Research Consortium?

The Department of Defense has over 12,000 contaminated sites that require some form of remediation. Current technologies, such as incineration and carbon adsorption, are hampered by the fact that they are either not cost effective or are politically unacceptable and, in the case of carbon adsorption, do not destroy the contaminant. Biological treatment technologies offer significant advantages since they are cheaper, destroy the contaminant of interest, and are more favorably received by the public.

The Strategic Environmental Research and Development Program (SERDP) was established when Congress enacted Public Law 101-510 in 1990. SERDP is the Department of Defense's premier technology development and transfer program. In October 1994, the Biological Treatment Research Consortium was funded by SERDP.

The Consortium is a task force of world-class research and development professionals from the U.S. Army, U.S. Air Force, U.S. Navy, the Department of Energy, the U.S. Environmental Protection Agency, and various universities. The Consortium's purpose is to rapidly develop promising biological treatment technologies for full-scale implementation at contaminated sites.

The consortium is focused on the following five major research areas: explosives, chlorinated solvents, polychlorinated biphenyls (PCBs), polycyclic aromatic hydrocarbons (PAHs), and biological reactors.

Due to the very nature of independent investigative research, soils that are studied often come from different contaminated sites. These soils contain different organisms as well as different physical and chemical characteristics. This research approach hampers the development of the biological remediation technology as it does not allow direct comparison with other competing technologies.

The consortium objective is to compare promising bioremediation technologies by doing research that uses the same contaminated matrices with similar analytical techniques. The biological technologies will be compared (that is, they will compete, or "horserace") against each other on an aggressive timeline that pushes the most successful technologies from bench to pilot scale. The idea is to develop the most promising technology for full-scale implementation. The consortium research methodology will speed the delivery of successful bioremediation technologies to contaminated sites.

Consortium structure

Consortium Director: Dr. Mark Zappi, U.S. Army Engineer Waterways Experiment Station

Bioreactor Development/Design: Dr. Mark Zappi, U.S. Army Engineer Waterways Experiment Station

Explosives Research: Dr. David Kaplan, U.S. Army Natick Research Development and Engineering Center

Chlorinated Solvents Research: Dr. Herb Fredrickson, U.S. Army Engineer Waterways Experiment Station

Phytoremediation: Dr. Steve McCutcheon, Environmental Protection Agency

PAH Research: Dr. Sabine Apitz, U.S. Navy

PCB Research: Dr. Jim Tiedje, Michigan State University

Pathways and Cloning Techniques: Dr. Jim Spain, Environmental Protection Agency

Microorganism Ecosystems: Dr. Doug Gunnison, U.S. Army Engineer Waterways Experiment Station

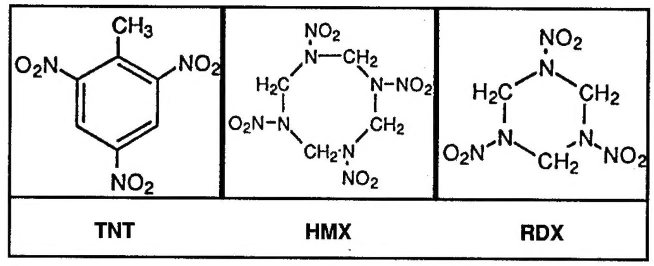
DoD EPA DOE SERDP
Strategic Environmental Research and Development Program

Improving Mission Readiness through Environmental Research

Federal Integrated Biotreatment Research Consortium
From Flask To Field
USEPA • USAir Force • USArmy • USNavy • DOE

The explosives horserace has begun!

The manufacture, packing, and use of explosives has resulted in numerous Department of Defense contaminated sites. The primary contaminants of interest are TNT (2,4,6-trinitrotoluene), HMX (octahydro-1,3,5,7-tetranitro-1,3,5,7-tetraocine), and RDX (hexahydro-1,3,5-trinitro-1,3,5-triazine).



Chemical structures of the primary explosive contaminants

Conventional treatment (incineration) is estimated to cost between $400 and $1,200 per cubic yard, while biological treatment using bioslurry and biocell systems is estimated at $90 to $200 per cubic yard and $20 to $100 per cubic yard, respectively.

Biological degradation of an explosive to form its basic inorganic components (carbon dioxide, water, and nitrate in the case of nitro-aromatics) is termed mineralization. The measurable loss of an explosive, such as TNT, from contaminated media is termed degradation. Degradation of TNT does not necessarily indicate that mineralization or even aromatic ring cleavage has occurred. Without complete mineralization occurring, intermediates (by-products) of TNT degradation may still be present.

To date, a microbial pathway responsible for complete mineralization of TNT using aerobic consortia has not been fully demonstrated. Earlier work by several investigators indicated that TNT can be biologically transformed into several by-products, some of which are more toxic than the parent TNT molecule. Some investigators have presented convincing evidence of a pathway for TNT mineralization, under anaerobic conditions.

During spring 1995, the U.S. Army Engineer Waterways Experiment Station began the most comprehensive study of explosives-contaminated soils ever conducted. The study examines the use of biotreatment for a number of regimes—anaerobic, anoxic, aerobic, surfactant amended, and bioaugmented—and in several reactor configurations—bio-slurry reactors (5-liter glass reactors with mixing) and biocell reactors (30-liter reactor without mixing).

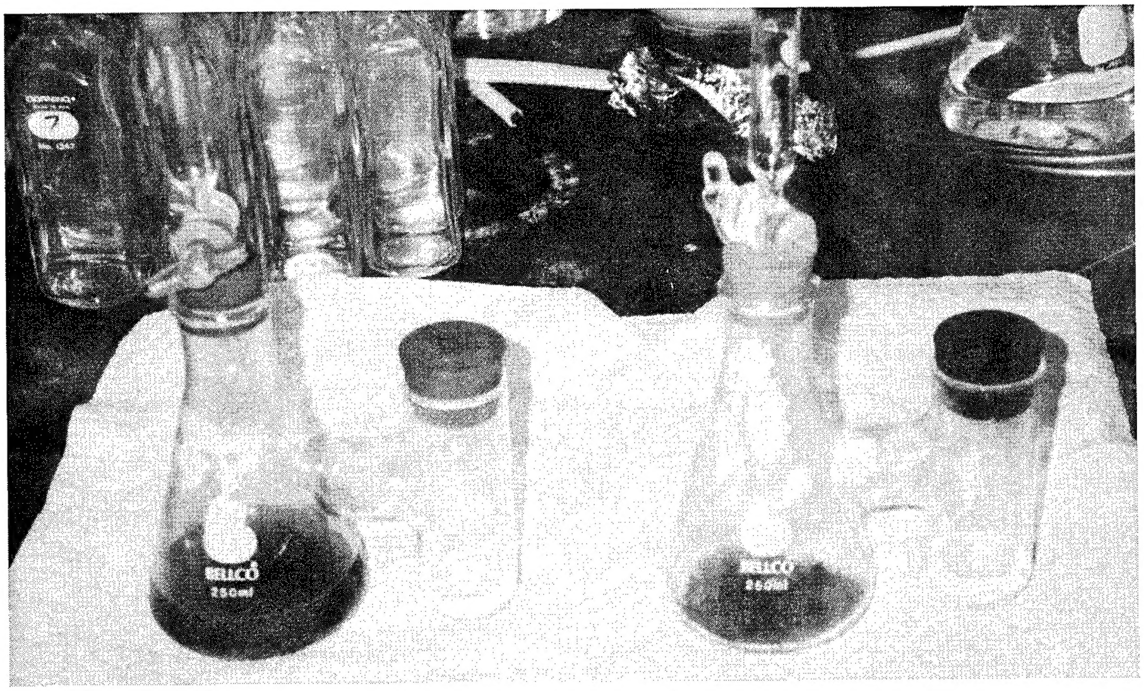
Study phases and some of their associated tasks are listed below:

Phase I: Soil sample selection and preparation

Phase II: Microbial systems evaluation

- Use of ^{14}C-labeled TNT to monitor degradation of TNT and formation of intermediates.

Biometric flasks are sampled for $^{14}CO_2$ in the KOH well. The flasks contain ^{14}TNT in soil and are kept in an anaerobic chamber to maintain appropriate conditions. (The dark plastic cover is removed for sampling and photographing)



Biometric flasks are used for the microbial experiments under Phase II

- Use of thin layer chromatography and autoradiography to determine ^{14}C-labeled products.
- Evaluate effectiveness of different cometabolic agents.
- Evaluate effectiveness of aerobic, anaerobic, and anoxic regimes.
- Evaluate effectiveness of adding enriched microbes to contaminated soil.

Phase III: Desorption enhancement evaluation

- Use of three surfactants in batch desorption studies to evaluate desorption enhancement of explosive compounds.
- Determination of the optimal surfactant concentration that sustains high explosives concentration in solution through sequential batch desorption experiments.

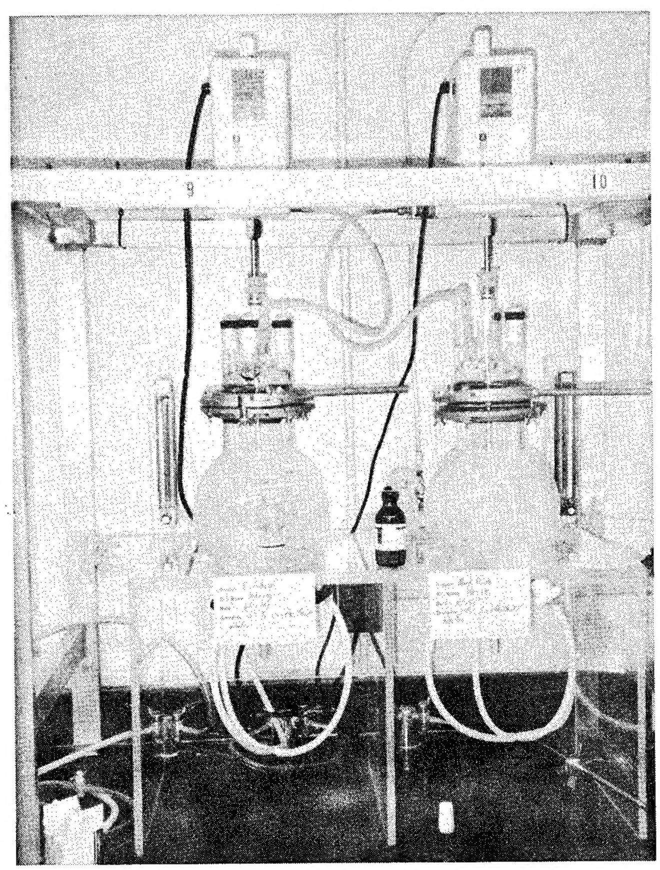
Phase IV: Bioslurry bench-scale studies

- Comparison of aerobic and anaerobic treatment regimes.
- Determination of amendment requirements.

Phase IV: Biocell bench-scale studies

- Comparison of aerobic and anaerobic treatment regimes.
- Determination of amendment requirements.

All phases of this explosives research will be completed by the end of September 1995. The technical report summarizing the study results is scheduled for publication in December 1995.



Two 5-liter bioslurry reactors. These reactors contain surfactant only at 0.5- and 5.0-percent concentrations to test an antifoam chemical prior to initiating the bioslurry bench-scale studies

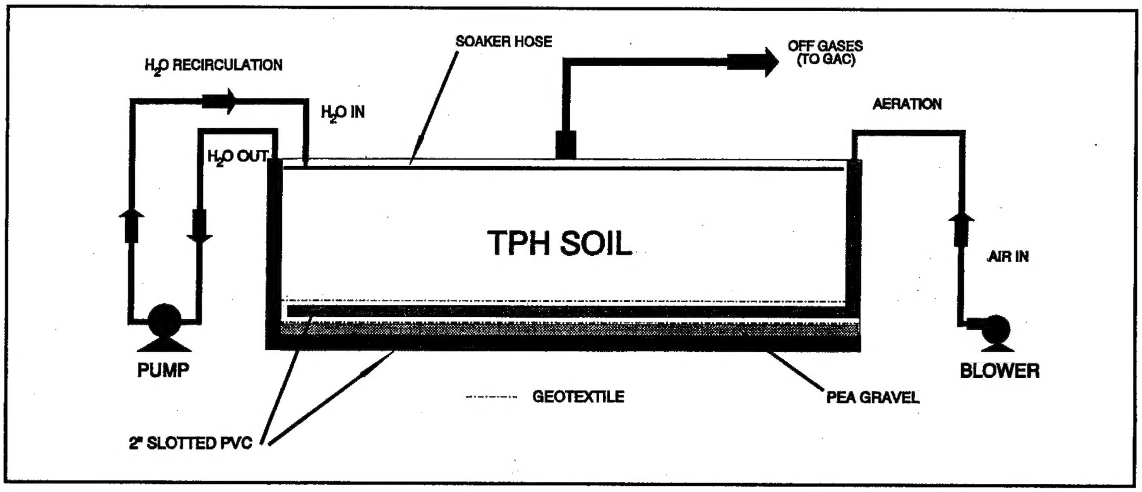
Technology Profile

Biocell treatment of TPH-contaminated soils

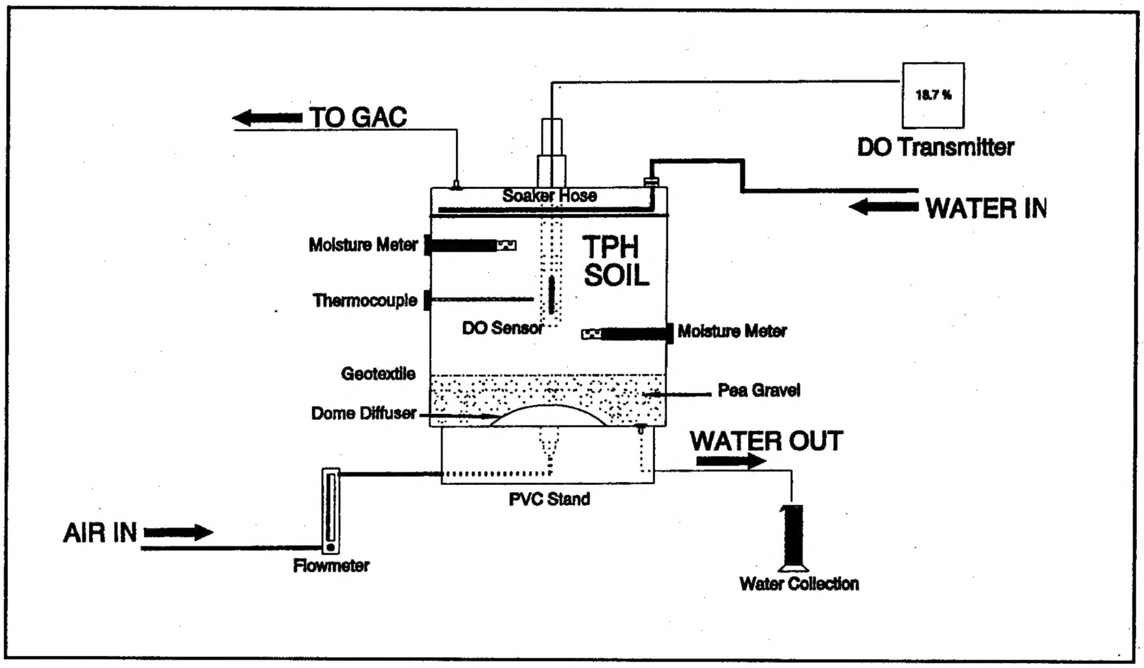
Low-level petroleum hydrocarbon contamination is found at many locations throughout the country, including Department of Defense installations and private sector (non-Federal) sites. Biocell treatment technology, currently being researched at the U.S. Army Engineer Waterways Experiment Station (WES), presents a low-cost, effective treatment alternative.

Biocells are converted roll-off dumpsters that treat contaminated soil after excavation. The concept uses well-understood aerobic bioremediation pathways and combines the best aspects of other treatment technologies such as landfarming and bioventing, with no concerns of groundwater contamination or volatilization to the atmosphere during treatment.

Bench-scale testing of biocells using 8-gallon steel drums is currently under way at WES to determine optimum conditions for the degradation of diesel-contaminated soil. Pilot testing with a converted 10-cubic yard dumpster is planned for the Hydrocarbon National Test Site in Port Hueneme, California, in September 1995.



a. Conceptual design of biocell



b. Bench-scale test cell

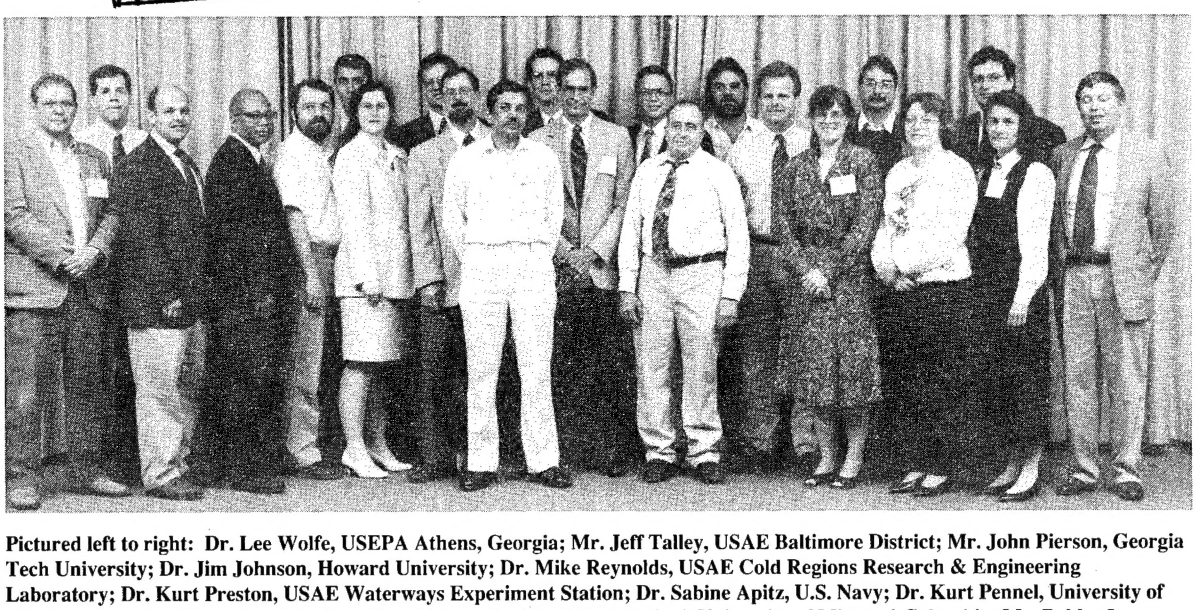
Design of the WES biocell

First SERDP Biotreatment Consortium meeting

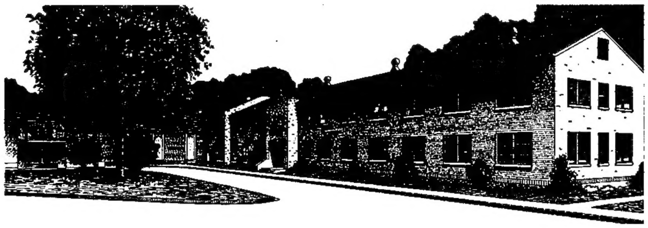
Participants in the first SERDP Biotreatment Consortium meeting gathered at the Waterways Experiment Station on March 13-17, 1995. The meeting was conducted as a "mini-conference," during which the bioconsortium researchers presented papers detailing their specific areas of research. Each of the 5 days was dedicated to one of the specific areas of interest (explosives, PCBs, PAHs, chlorinated solvents, and reactor design). The presentations focused on the individual researcher's activities and analytical techniques.

The week-long conference helped unite the bioconsortium members into a strong team, ready to solve the numerous complex remediation issues.

Current Consortium Membership	
Dr. Mark Zappi Dr. Doug Gunnison Dr. Herb Fredrickson Dr. Judy Pennington	U.S. Army Engineer Waterways Experiment Station, Environmental Laboratory, Vicksburg, MS
Dr. David Kaplan	U.S. Army-Natick RD&E Center, Natick, MA
Mr. Jeff Talley	USAE Baltimore District, Baltimore, MD
Dr. Jim Spain Ms. Cathy Vogel	U.S. Air Force, Armstrong Lab, Tyndall Air Force Base, Panama City, FL
Dr. Michael Reynolds	USAE Cold Regions Research and Engineering Laboratory, Hanover, NH
Mr. Mark Hampton	Army Environmental Center, Aberdeen Proving Ground, MD
Dr. Sabine Apitz	U.S. Navy/NRAD, San Diego, CA
Dr. John Wilson	U.S. Environmental Protection Agency, R.S. Kerr Laboratory, Ada, OK
Dr. Joanne Jones-Meehan	Naval Surface Warfare Center, Dahlgren, VA
Dr. Steve McCutcheon	U.S. Environmental Protection Agency, Environmental Restoration Laboratoy, Athens, GA
Dr. Hap Pritchard	U.S. Environmental Protection Agency, Environmental Restoration Laboratory, Gulf Breeze, FL
Dr. Byung-Joon Kim	U.S. Army Construction Engineering Research Laboratories, Champaign, IL
Mr. Fred Bishop	U.S. Environmental Protection Agency, RREI, Cincinnati, OH
Dr. John Manning	U.S. Department of Energy, Argonne National Laboratory, Germantown, NJ
Dr. Jim Johnson	Howard University
Dr. Walter Weber	University of Michigan
Dr. Jim Tiedje	Michigan State University



Pictured left to right: Dr. Lee Wolfe, USEPA Athens, Georgia; Mr. Jeff Talley, USAE Baltimore District; Mr. John Pierson, Georgia Tech University; Dr. Jim Johnson, Howard University; Dr. Mike Reynolds, USAE Cold Regions Research & Engineering Laboratory; Dr. Kurt Preston, USAE Waterways Experiment Station; Dr. Sabine Apitz, U.S. Navy; Dr. Kurt Pennel, University of Michigan; Dr. Jim Champine, Michigan State University; Dr. Rakesh Bajpai, University of Missouri-Columbia; Mr. Bobby Jones, USAE Waterways Experiment Station; Dr. Jim Tiedje, Michigan State University; Dr. John Quinson, Michigan State University; Dr. Mohammad Quasim, USAE Waterways Experiment Station; Dr. Carlos Ruiz, USAE Waterways Experiment Station; Dr. Robert Steffan, Envirogen; Dr. Joanne Jones-Meehan, U.S. Navy; Dr. Herb Fredrickson, USAE Waterways Experiment Station; Ms. Charlene Mello, U.S. Army Natick RD&E Center; Dr. Mark Zappi, USAE Waterways Experiment Station; Ms. Cindy Teeter, USAE Waterways Experiment Station; Mr. John Walker, U.S. Army Natick RD&E Center



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